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| 10/822,016 | 04/08/2004 | Chris M. Carlson | MI22-2449 | 1689 |

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| EXAMINER | |
|---|---|
| VETERE, ROBERT A | |

| ART UNIT | PAPER NUMBER |
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**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

| Office Action Summary | Application No. | Applicant(s) | |
|---|---|---|---|
| | 10/822,016 | CARLSON ET AL. | |
| | Examiner | Art Unit | |
| | ROBERT VETERE | 1792 | |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on *10/1/08*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *10-15,20,28,31,33 and 87* is/are pending in the application.

4a) Of the above claim(s) *10,11,31 and 33* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *12-15,20,28,87* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

## DETAILED ACTION

### *Claim Rejections - 35 USC § 103*

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 14-15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lee et al. (2004/0238872, hereinafter "Lee") in light of Lee et al. (US 7,151,039, hereinafter "Lee II") and further in light of Yamamoto (US 6,936,901) and further in light of Ahn et al. (US 7,135,421).

**Claims 14-15**: Lee teaches a method of forming a high-k dielectric layer comprising hafnium aluminum oxide using ALD (¶ 0043), wherein a silicon substrate is loaded on a wafer stage of an ALD apparatus (¶ 0043), a pulse of a first precursor containing a first element (e.g., Hf) is supplied and chemisorbed onto the substrate (¶ 0043) to form a monolayer (¶ 0043, Fig. 6), the part of the first precursor not absorbed is exhausted from the apparatus (¶ 0043), a pulse of a second precursor containing a second element (e.g., Al) is supplied and chemisorbed into the first element of the first precursor (¶ 0043, Figs. 7-8), the part of the first precursor not absorbed is exhausted from the apparatus (cl. 3), providing a reactant (e.g., Ozone) which reacts with both the first and second elements to form a high-k dielectric layer that contains both the first and second elements (¶ 0046) and exhausting the ALD apparatus to remove the excess reactant (cl. 2).

Lee also teaches that the Al-containing precursor is TMA (¶ 0043) and that the oxidant is $O_3$ (¶ 0046). What it does not teach is that the Hf-containing precursor is TMEAH or TDMAH. Lee II teaches a method of forming an oxide layer using ALD (Col. 2: 58-67) containing, for example, Al and/or Hf (3:9-11), wherein the hafnium-containing precursor is TDMAH (i.e. $Hf[N(C_2H_5)_2]_4$) or tetrakis-ethylmethylamino hafnium (i.e. $Hf[NC_2H_5CH_3]_4$, claimed TMEAH) (3:12-15). Furthermore, the selection of a known material based on its suitability for its intended use supported a prima facie obviousness determination in *Sinclair & Carroll Co. v. Interchemical Corp.*, 65 USPQ 297 (1945). Thus, it would have been obvious to one of

ordinary skill in the art at the time the invention was made to have used either TDMAH or TMEAH as the hafnium-containing precursor in the method of Lee with the predictable expectation of successfully forming a high-k dielectric layer containing hafnium and aluminum.

Lee also fails to teach that the aluminum-contain precursor is provided before the hafnium-containing precursor. Yamamoto teaches a method of forming oxide layers of aluminum (8: 43-60) and hafnium (8:61-9:8) using ALD (see, e.g., 8:20) wherein the aluminum is introduced before the hafnium. Furthermore, the teaching of Lee is not confined to introducing hafnium before aluminum because Lee teaches only teaches that first precursor contains hafnium *e.g.* (see ¶ 0043, line 5) and likewise with the second precursor (see ¶ 0043, lines 13-14). Thus, because both Lee and Yamamoto teach methods of using ALD to form oxide layers comprising aluminum and hafnium, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have introduced aluminum before hafnium, as taught by Yamamoto, with the predictable expectation of successfully forming a high-k dielectric layer.

Lee also fails to teach that the pulse sequence of TMA-(TMEAH-$O_3$)$_x$, where x is at least two. Ahn teaches a method of forming a layer of hafnium aluminum oxide using ALD and also that in order to control the dielectric constant of the layer, it is best to control the number of cycles of hafnium-reactant relative to the number of cycles of aluminum (13:20-44). "[W]here the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation." *In re Aller*, 105 USPQ 233, 235 (CCPA 1955). Thus, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have controlled the number of cycles of TMEAH-$O_3$ using, for example, 2 or more sequences, in order to obtain the desired dielectric constant in that layer.

3. Claims 12-13, 28, 28 and 87 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lee, in light of Lee II and further in light of Yamamoto.

**Claims 12-13, 20, 28 and 87**: Lee teaches a method of forming a high-k dielectric layer comprising hafnium aluminum oxide using ALD (¶ 0043), wherein a silicon substrate is loaded on a wafer stage of an ALD apparatus (¶ 0043), a pulse of a first precursor containing a first element (e.g., Hf) is supplied and chemisorbed onto the substrate (¶ 0043) to form a monolayer (¶ 0043, Fig. 6), the part of

the first precursor not absorbed is exhausted from the apparatus (¶ 0043), a pulse of a second precursor containing a second element (e.g., Al) is supplied and chemisorbed into the first element of the first precursor (¶ 0043, Figs. 7-8), the part of the first precursor not absorbed is exhausted from the apparatus (cl. 3), providing a reactant (e.g., Ozone) which reacts with both the first and second elements to form a high-k dielectric layer that contains both the first and second elements (¶ 0046) and exhausting the ALD apparatus to remove the excess reactant (cl. 2). Lee also teaches that the reactant can be nitrogen-containing (see, e.g., ¶ 0052).

Lee also teaches that the Al-containing precursor is TMA (¶ 0043) and that the oxidant is $O_3$ (¶ 0046). What it does not teach is that the Hf-containing precursor is TMEAH or TDMAH. Lee II teaches a method of forming an oxide layer using ALD (Col. 2: 58-67) containing, for example, Al and/or Hf (3:9-11), wherein the hafnium-containing precursor is TDMAH (i.e. $Hf[N(C_2H_5)_2]_4$) or tetrakis-ethylmethylamino hafnium (i.e. $Hf[NC_2H_5CH_3]_4$, claimed TMEAH) (3:12-15). Furthermore, the selection of a known material based on its suitability for its intended use supported a prima facie obviousness determination in *Sinclair & Carroll Co. v. Interchemical Corp.*, 65 USPQ 297 (1945). Thus, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have used either TDMAH or TMEAH as the hafnium-containing precursor in the method of Lee with the predictable expectation of successfully forming a high-k dielectric layer containing hafnium and aluminum.

Lee also fails to teach that the aluminum-contain precursor is provided before the hafnium-containing precursor. Yamamoto teaches a method of forming oxide layers of aluminum (8: 43-60) and hafnium (8:61-9:8) using ALD (see, e.g., 8:20) wherein the aluminum is introduced before the hafnium. Furthermore, the teaching of Lee is not confined to introducing hafnium before aluminum because Lee teaches only teaches that first precursor contains hafnium *e.g.* (see ¶ 0043, line 5) and likewise with the second precursor (see ¶ 0043, lines 13-14). Thus, because both Lee and Yamamoto teach methods of using ALD to form oxide layers comprising aluminum and hafnium, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have introduced aluminum before hafnium, as taught by Yamamoto, with the predictable expectation of successfully forming a high-k dielectric layer.

The combination of Lee, Lee II and Yamamoto, however, fails to expressly teach that the utilization of TMA improves conformatlity relative to the conformatlity that would exist in the absence of TMA. This limitation, however, if inherently contained in these references because the method taught by the combination of Lee, Lee II and Yamamoto is identical to the method claimed by applicants in claims 20 and 87.

***Response to Arguments***

4. Applicant's arguments filed 10/01/2008 have been fully considered but they are not persuasive.

Applicant first argues that Lee does not disclose the introduction of TMA in the first pulse or the repeated rounds of Hf precursor followed by ozone and that none of the secondary references correct this deficiency. This is not persuasive. While Lee fails to teach that TMA is the first pulse or that the repeated rounds of Hf followed by ozone are sequenced as TMA-(TMEAH-$O_3$)$_x$, the combination of references cited above in paragraph 2 of this action teach both of these limitations.

Applicant next argues that none of the cited references teaches that the reactant comprises silicon or nitrogen. This is not persuasive. Lee teaches that the reactant can comprise nitrogen is an oxynitride layer is desired (see, e.g., ¶ 0052).

Finally, applicant argues that the recited improvement in claim 87 (improved conformality) is not inherent in Lee and that none of the combined references contribute toward the cited improvement. This is not persuasive. The combination of references cited above with respect to claim 87 teach the same method as claim 87 and, therefore, it is inherent that the combined method will result in improved conformality.

***Conclusion***

5. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action

is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ROBERT VETERE whose telephone number is (571)270-1864. The examiner can normally be reached on Mon-Fri 9-6.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Michael Cleveland can be reached on 571-272-1418. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Robert Vetere/
Examiner, Art Unit 1792

/Michael Cleveland/
Supervisory Patent Examiner, Art Unit 1792